IMAGE COMPRESSION

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims priority from provisional application Appl. No. 60/279,469, filed 03/28/01. The following pending US patent applications disclose related subject matter and have a common assignee with the present application: Serial No. 09/...., filed __/__/____.

BACKGROUND OF THE INVENTION

This invention relates to integrated circuits, and more particularly, to integrated circuits and image and video compression methods.

Recently, Digital Still Cameras (DSCs) have become a very popular consumer appliance appealing to a wide variety of users ranging from photo hobbyists, web developers, real estate agents, insurance adjusters, photo-journalists to everyday photography enthusiasts. Recent advances in large resolution CCD arrays coupled with the availability of low-power digital signal processors (DSPs) has led to the development of DSCs that come quite close to the resolution and quality offered by traditional film cameras. These DSCs offer several additional advantages compared to traditional film cameras in terms of data storage, manipulation, and transmission. The digital representation of captured imges enables the user to easily incorporate the images into any type of electronic media and transmit them over any type of network. The ability to instantly view and selectively store captured images provides the flexibility to minimize film waste and instantly determine if the image needs to be captured again. With its digital representation the image can be corrected, altered, or modified after its capture. See for example, Venkataraman et al, “Next Generation Digital Camera Integration and Software Development Issues” in Digital Solid State Cameras: Design and Applications, 3302 Proc. SPIE (1998). Similarly, USP 5,528,293 and USP 5,412,425 disclose aspects of digital still camera systems including storage of images on memory cards and power conservation for battery-powered cameras.

Further, DSCs can be extended to capture video clips (short video sequences) and to compress images/video with methods such as JPEG for (sequences of) still

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images and MPEG for video sequences. In DCT-based video compression such as H.261, H.263, MPEG1, MPEG2, and MPEG4, or image compression such as JPEG, a picture is decomposed into macroblocks. Each macroblock contains a certain number of 8x8 blocks, depending upon the chroma-format used. For example, in the case of 4:2:0 chroma-format a macroblock is made up of four 8x8 luminance blocks and two 8x8 chrominance blocks. Figure 3 depicts in block diagram a DCT-based video or image sequence encoding camera system. In order to reduce the bit-rate, 8x8 DCT (discrete cosine transform) is used to convert the blocks into the frequency domain for quantization. The first coefficient in an 8x8 DCT block is called the DC coefficient; the remaining 63 DCT-coefficients in the block are called AC coefficients. The DCT-coefficient blocks are quantized, scanned into a 1-D sequence, and coded by using variable length coding (VLC). For predictive coding in which motion compensation (MC) is involved, inverse-quantization and IDCT are needed for the feedback loop.

In some cases, however, processors may have limited processing power, which could make real-time video or still-image sequence encoding impossible. Similarly, other digital cameras, such as cameras in a network, may have limited processing power which impairs video encoding.

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SUMMARY OF THE INVENTION

The invention provides a video and/or image compression based on strips of (macro)blocks and includes decisions to encode a strip or approximate it by an already-encoded corresponding strip of a prior frame and/or image.

This has advantages including reduction in encoding complexity and/or reduction in memory requirements without significant video and/or image coding quality degradation.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings are heuristic for clarity.

Figure 1 illustrates preferred embodiment compression.

Figure 2 shows a preferred embodiment camera system.

Figure 3 shows a camera system.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

1. Overview

The preferred embodiment video compression/decompression methods efficiently encode sequences of JPEG images. The methods use the correlation between successive frames to create a space efficient intermediate format consisting of a bitmap and bitstream segments. Because JPEG encodes images as rows of 8x8 (or 16x16) blocks, the image is divided into image region strips consisting of successive rows of blocks, a single row of blocks, or part of a row of blocks. Each strip is represented either by (1) the usual JPEG bitstream segment or (2) an approximation by the corresponding bitstream segment from a previous image. The method's bitmap includes a value for each strip that indicates which of these two representations is used. When the image is retrieved, the bitmap is used to coordinate interleaving the appropriate bitstream segments.

The methods may bit pad and insert a JPEG restart marker at the end of each strip bitstream segment. This provides byte alignment for the bitstream segment which makes segment storage, retrieval, and interleaving much more efficient.

2. DC coefficient preferred embodiments

Figure 1 illustrates a first preferred embodiment encoding and decoding for a sequence of frames (images). Selecting which strips of an image to encode and which to approximate with a previous image strip impacts both the resulting image quality and the encoding complexity. The first preferred embodiment method uses DC coefficient differencing between two consecutive images to determine whether or not to store information for that strip. The definition of the strips could be simple, such as a fixed number of (macro)blocks, or customized to suit the capabilities of a particular realization. Indeed, during compression, image data is typically buffered, i.e., groups of blocks are transferred successively to an internal memory buffer with burst memory transfers (e.g., direct memory access, DMA). It is useful to select the strip size to be no greater than this buffer size so that the associated strip processing can be accomplished within a single memory transfer.

The preferred embodiment encoder works as follows: Every few (e.g.. 5-20) frames, a complete JPEG image is encoded (the key frame). The DCT coefficients of the blocks corresponding to each strip of the key frame are maintained in memory. The next frame's DCT coefficients (or only the DC coefficient) for blocks of each strip are then computed. The DC coefficient of each block of the strip is then differenced with that of the corresponding block of the strip of the key frame and (absolute value) compared to a threshold. The decision to encode the strip is made if the sum of the DC coefficient differences over the blocks in the strip or the maximum DC coefficient difference over the blocks of the strip is below the threshold. A bit mask with one bit corresponding to each strip is then stored with each subsequent image (until the next key frame) – where a 1 indicates the strip is encoded and a 0 indicates the strip is not encoded. The rest of the compressed image then contains the bitstream segments from the strips which need to be compressed.

When a particular image is recalled from storage, the processor reconstructs the image based on the coding bitmap, the additional bitstream segments of encoded strips, and the previously fully compressed and strip-indexed key image. Further, because the Huffman labels are the same across all images, it is possible to inject parts of the Huffman streams for individual strips from previously compressed images.

3. Systems

The preferred embodiment methods are well suited for environments in which require continuous compression and storage of video or sequences of images which contain only partial spatial updates. Figure 2 illustrates functional blocks of a preferred embodiment surveillance camera system which incorporates the preferred embodiment compression of the sequence of images captured by the CCD camera. Note that the memory/storage could be removable and the retrieval/display could be physically disconnected from the camera/compression with each subsystem including a controller. The methods are well suited for DSPs which can quickly perform DCTs but take a long time for variable length coders such as Huffman. The methods require significantly less time in coding and less storage media. The methods provide a mechanism to permit

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faster JPEG encoding, which is often a critical limitation on systems, in exchange for slightly slower image retrieval.

4. Modifications

The preferred embodiments can be varied while maintaining the features of analysis of DCT (e.g., DC coefficients) of blocks in a strip of an image to decide whether to encode as (quantized) DCT coefficients (plus possible variable length encoding) or as an approximation of an-already-encoded corresponding strip in a prior image.

For example, other partitions of an image into strips, such as multiple strip partitions with a few bits attached to the key frame to select which partitioning into strips is being used. Also other measures of error, such as sums of squares could be used in place of absolute values for the coding decision. More than just the DC coefficients could be used in the coding decision; for example, the DC coefficient plus the three lowest AC coefficients could all be differenced and thresholded. Analogously, initially only the DC coefficients could be computed and the decision as to whehter to encode or to repeat the prior strip could be made prior to any full DCT coefficient computation needed for the blocks of the strip. Further, wavelet and other transform methods could be used in place of DCT with analogous coefficient analysis for encoding decisions.